What are we looking for? Research being conducted.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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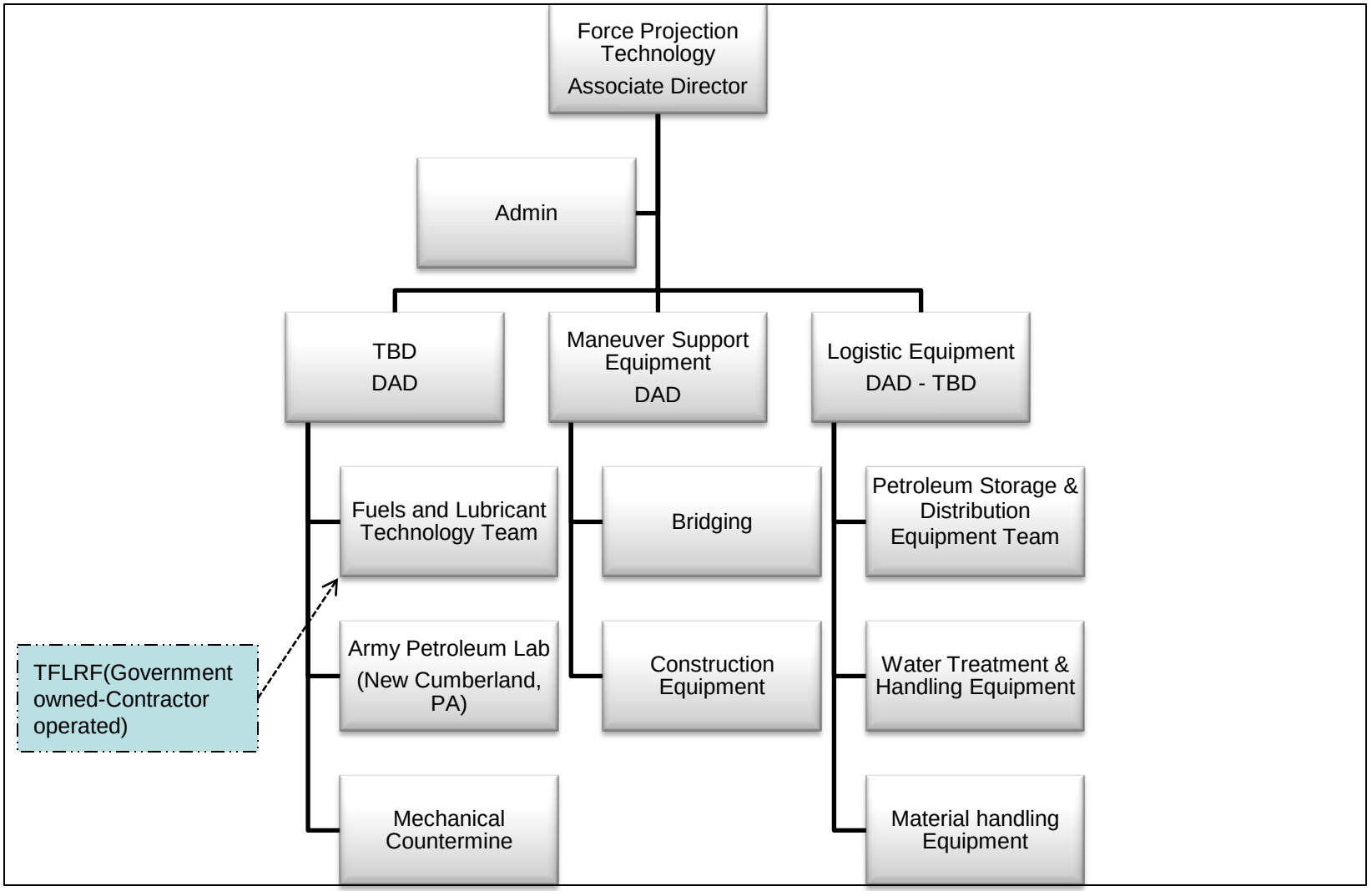
Agenda

- Force Projection Technology Organization
- Ground Fleet Primary Issues
- Independent Laboratory Independent Research (ILIR) Projects
  - Nanoparticle modeling in coolant systems
  - Heat Transfer Molecular Simulations of Nanofluids
- Single Lube in the Battlefield
  - What have we demonstrated
- Fuels – Alternative fuels and how they fit in the military

FPT Org Chart



Ground Fleet Interest
POL Perspective

- Fuel Economy
- World Wide World Operability : -40F to 140F ambient
- Improved Reliability
- Sensors for Condition Based Maintenance (CBM)
- Reduce Logistics
  - Reduce Fuel consumption
  - Extend Fluid Drain Intervals
  - Reduce waste generation
  - Simplify maintenance requirements
- Thermal Management
  - Improve thermal efficiency
- Use of Alternative Fuels – Minimize petroleum dependency

In-house Laboratory Independent Research (ILIR)

Thermal Conductivity Modeling of Nano coolants

- The objectives of this research are to develop a new model for predicting thermal conductivity of nanoparticle fluids by incorporating particle properties, and develop suitable analytical methods to experimentally investigate the nanofluid systems, particle characteristics, and preparation methods for controlling nanofluid properties.

Thermal Conductivity

$$k_f = \frac{q}{4\pi} \frac{d \ln t}{d \Delta T}$$

- How/What do we include the contribution of nano-particles?
  - Agglomeration impact?
  - Particle Size?
  - Particle type?

Heat Transfer Molecular Simulations of Nanofluids

- GENERAL:
  - Understanding of the underlying mechanisms for thermal transfer and friction and wear of nanofluids is limited. Work will conduct molecular dynamics simulation to elucidate the underlying atomic scale behavior responsible for these phenomena.
- OBJECTIVE:
  - Develop a molecular model and conduct simulations of the following fluids and mixtures:
    - Water
    - Ethylene glycol
    - Water and aluminum oxide nanoparticles
    - Ethylene glycol and aluminum oxide nanoparticles
  - Identify the fundamental mechanism of heat transfer and quantify transport properties such as the effective thermal conductivity and kinematic viscosity. The model and simulation should also elucidate the role of thermal contact resistance between solvent and particle and help to investigate other proposed heat transfer mechanisms such as Brownian motion induced convection.

Single Common Powertrain Lubricant (SCPL)

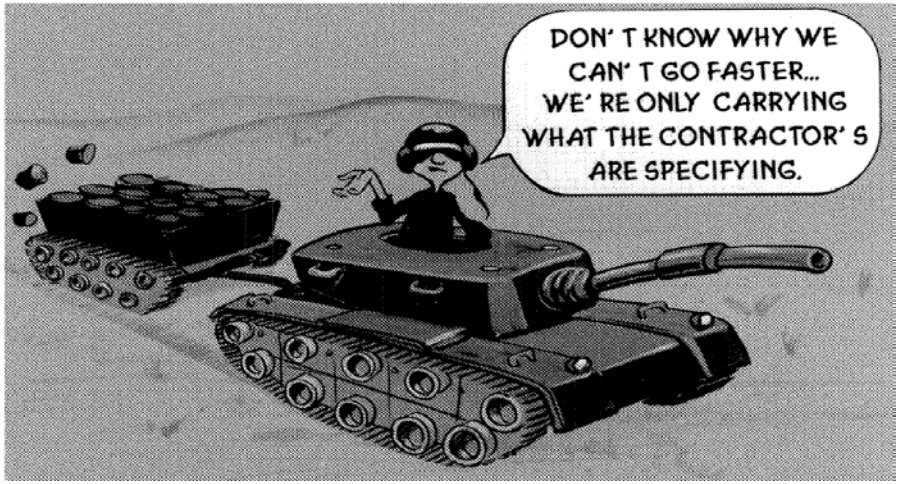
Single Common Powertrain Lubricant

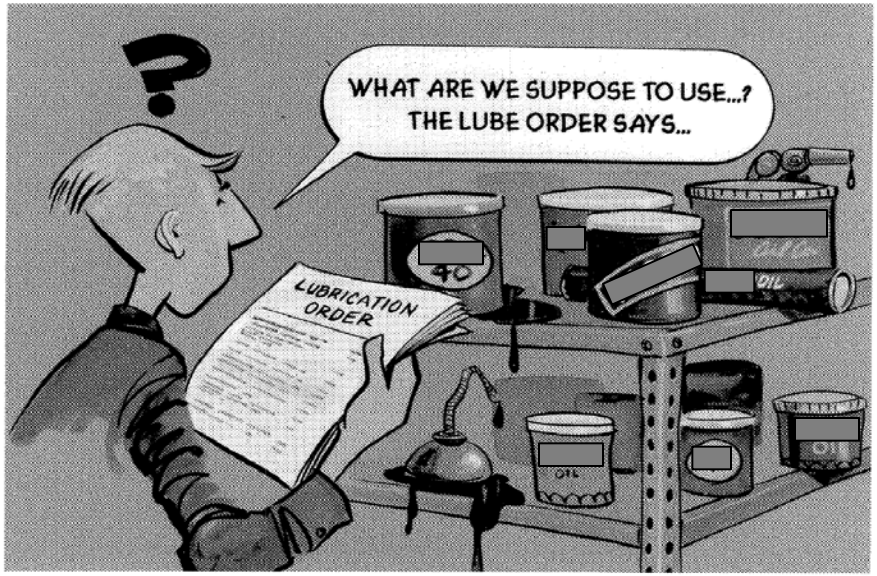
- One Grade only
  - likely 0W-30 (20/or 40 are being considered)
- Improve Fuel Efficiency
  - As little as 0.5% improvement in fuel economy can result in saving more 1 million gallons of fuel per year
- Arctic-to-Desert application
- Multi-component Use
  - Engine
  - Transmission
  - Hydraulics
- Reduce number of stock numbers needed from 15 to 3
  - Each different grade can have 3 or more NSN listed in the inventory
- Engine and transmission testing supports the technical feasibility of such an oil

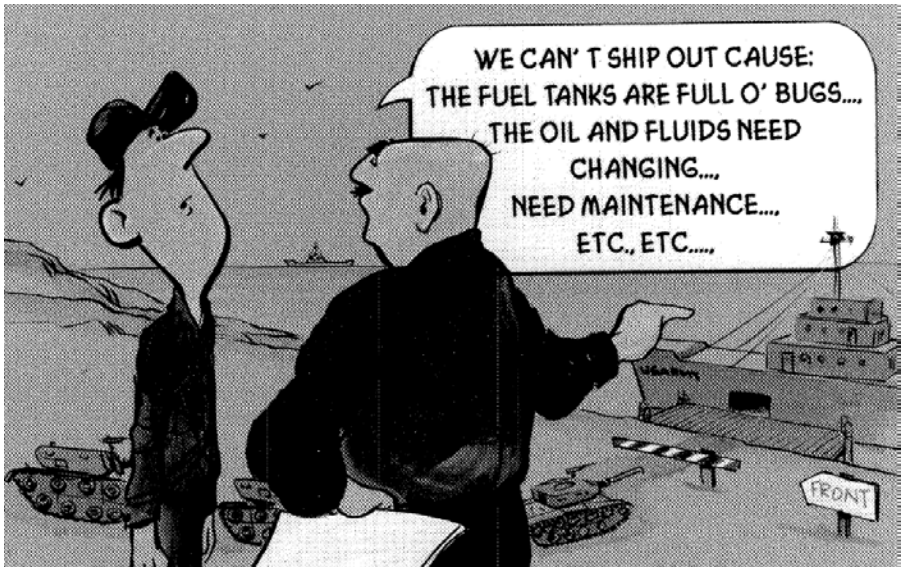
Engine testing

- First generation SCPL completed:
  - High Fluid temperature using 210hr Tactical Wheel Vehicle Cycle
  - Avg 265ºF oil sump
  - Avg 215ºF coolant
  - Engines tested
    - 6.5 L HMMWV Engine
    - In-Line, 6 cyl, 14.0 L Engine
    - In-Line, 6 cyl, 7.2L Engine
- Series of transmission tests not currently in specification
  - Assessment on performance of fluids in transmission:
    - Various automatic & heavy-duty transmission tests; brake chatter test also
  - Potential to include another test in spec
  - Overall results showed military qualified oils behave better than anticipated.
    - Although parameters of some of the tests were considered fail, failure was due to being only slightly out of the limits. No catastrophic or serious problems.
    - Only one oil had to be stopped on the Brake Chatter test – Formulation not currently available.

Single Common Powertrain Lubricant (SCPL) Program







Alternative Fuels

- Synthetic SPK
- Biodiesel

Alternative Fuels: SPK

These tests have been completed: (WD 23)

TWV Pilot Demonstration at Ft. Bliss, TX *(2009)*
- half fleet on JP-8, half fleet on SPK/JP-8 blend
- miles driven per training protocol
- no issues

HMMWV Test Track Evaluation *(2009)*
- 6.5L non-turbo evaluated
  - loaded vs. unloaded
  - uphill vs. flat vs. downhill
  - on-road vs. off-road
  - DF2 / JP-8 / S8 / 1:1 blend
  - noticeable acceleration loss using blend

In-Line, 6-cyl, 7.2L Engine Performance Test *(2007)*
- ULSD / JP-8 / S-8 / 1:1 blend
- 2 x 210 hr TWV dyno test performed on S-8
- no issues

TARDEC photo by R. Alvarez,
TARDEC Fuels & Lubricants Research Facility

TeamBliss

Alternative Fuels: SPK

Laboratory Evaluations at Contractor and F&L Labs *(2006 – 2009)*

- O-Ring Swelling
- Lubricity Database
- Properties of Fuel Blends
- Cetane Evaluations
  - Laboratory
  - Engine
  - Derived

Generator Set testing at Contractor *(2007)*

- three 10-kW gen sets
- 1000 hrs total test time
- JP-8 / S-8 / 1:1 blend
- no issues

Engine Performance Comparison at Contractor *(2008)*

- 7.2L and 6.5L engines tested
- same fuel as from TWV Pilot Demo
  - JP-8 and 1:1 blend compared
- power curves obtained
  - 7.2L – no loss
  - 6.5L – noticeable loss

Rotary Fuel Pump Tests at Contractor *(2004)*

- S-5 vs. LSD
- pump operated for up to 500-hrs
- untreated S-5 failed the pump after ~150 hrs

Alternative Fuels: SPK

- **Engines are evaluated for power before, during, and after 400-hr NATO test**
- **Elevated temperatures used in all tests (except 6.5L engine test) to simulate desert conditions**

Completed Tests: *(2008 - 2009)*

✓6.5 L Turbo SPK blend
HMMWV

✓7.2L SPK blend
Stryker

Engines Still to be Tested:

➢V-12,4-stroke, diesel???
Recovery Vehicle

➢In-Line, 6 cyl, 7.6/9.3L ???
MRAP

Engines Currently Being Tested:

✓In-Line, 6 cyl, 8.3L SPK blend
Bradley

✓V-8, 12.1L SPK blend
HEMTT

All engine testing performed at TARDEC Ground Vehicle Power and Mobility Propulsion Laboratory, Warren, MI

Power curves taken after break-in and after each 100 hrs operation. Test requires WOT operation as well as part-throttle, max load and idle. Desert conditions include ~170˚ F fuel and 120˚ F ambient conditions.

Alternative Fuels: SPK

Gen sets use the most fuel in the Army during wartime

Met with CERDEC to determine which gen sets to test and how

MIL-STD-705C

2-kW	15-kW (2 types)
3-kW	60-kW
10-kW	100-kW

Tests to be Conducted		*Where to test?*
Electrical Characteristics	TM 608.1	Aberdeen PG
	TM 608.2 (new temps req'd)	Aberdeen PG
	TM 630.1	Aberdeen PG
Rated Load	TM 720.1	Aberdeen PG
Altitude Operation	at 4000 ft, 95° F	
Maximum Power	at 10,000 ft, 95° F	
Reliability	TM 695.1	Contractor lab
Environmental	TM 710.1 at 125° F	Aberdeen PG
Fuel Consumption	TM 670.1	Aberdeen PG

Alternative Fuels: SPK

- More work to be done
- Support equipment needs to be addressed
- Other synthetics coming up – HRJ, 2nd gen biodiesels
- Knowledge of current equipment and fuels still needed
  - Defining what are key/performance parameters in the fuel as they impact operation, performance, efficiency of vehicles/engines
- Currently working to include cetane and viscosit at 40° C in JP-8 spec
  - Only for SPK portion
  - Tested SPK fuels have high cetane (except for one) and desired visc at 40° C
    - Influenced by manufacturing process!

Alternative Fuels: Biodiesel

- US Army has not approved the use of biodiesel blends in tactical equipment
- Only one Army location officially field testing biodiesel in tactical vehicles
  - Site visit showed unofficial controls by all participants contribute to success of test. This cannot be viewed as representative for all potential locations
- Air Force and Navy has had problems when using biodiesel blends across their fleets
  - Filter plugging
  - Microorganism growth
  - Gelling at low temperatures
- Tri-Service POL Users Group recommended biodiesel should not be used in tactical equipment until identified areas of concerns are addressed and corrected(solutions ID)

Alternative Fuels: Biodiesels

Alternative Fuels: Biodiesel

- Environmental Security Technology Certification Program (ESTCP) – On-going
  - Field Demonstration of biodiesel use in tactical vehicles
  - Proposed by Navy Environmental Group
  - Not directly addressing issues identified by Tri-Service
  - Army interest to ID parameters, requirements, and controls that would need to be in place for a successful use of bio-diesel.
- Locations :
  - Port Huaneme
  - 29 Palms
  - Moody AFB
  - Crane Naval Warfare Center
- Issues:
  - Variety of manufacturing techniques
  - Fuel crossing seasons creating gelling problems
  - Cholesterol and glycerides ID as problematic components